BREAKING THE SHORAD PARADIGM: NEW ENGAGEMENT OPPORTUNITIES FOR FIRE UNITS

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Introduction

SGT Adams was just getting ready to catch a few moments of sleep when PFC Carpenter called for him. "Hey Sarge, you better get up. We just got a Dynamite warning, and the LT wants us to stand by for target designation. Looks like them Hokums are gonna come for us tonight!" Adams was supporting the 3rd BCT of the 54th Mobile Strike Force. They, along with their Baltican allies, had been making good progress all day in their effort to push the Atlanticans out of Baltica, Adams was trying to get some rest while the 3rd BCT was momentarily paused. Now it appeared that the Atlanticans were going to try to stop the attack with a night strike from its squadron of HA-50 Hokum attack helicopters. Equipped with the AT-9, the Hokums could stand-off outside the range of friendly SHORAD units and pick off the vehicles of 3rd BCT at will, especially at night. But all of that was about to change.

"Well we've got a surprise for 'em tonight Carpenter. Let those Hokums get a taste of our new missiles. Jones, wake-up and let's get moving." Adams' unit was the first equipped with the U.S. Army's new Blitzer. The Blitzer was a Linebacker with slew-to-cue capabilities and the STINGER missiles replaced with the AIM-120 AMRAAM. The platoon command post also had the new SHORAD Fire Direction Center, which could exercise SHORAD fire control and assign targets digitally to the fire units. The Hokums were flying into an integrated SHORAD Air Defense of system with all-weather, day and night capability, and most importantly, a range of over 20 kilometers.

In the platoon fire direction center the lieutenant was watching his screen as 12 hostile targets moved steadily toward his AO. He had designated the trailing 4 aircraft to his platoon of 4 Blitzers, and was waiting for the targets to get in range to spring his trap. As the final aircraft got within 20 kilometers of his platoon's positions, he sent the fire commands.

"Fire!" ordered SGT Adams and PFC Carpenter pulled the trigger on his control. The AMRAAM missile streaked away into the night, its active seeker locked on the unsuspecting enemy helicopter. Moments later 4 of the Atlantican's most valued night fighting platforms went down in flames, as the Blitzers were already locking on and engaging the remaining 8 aircraft. In a matter of 4 minutes 10 Hokums were burning heaps on the battlefield and the last 2 were limping home without delivering their ordnance. 3rd BCT wasn't going to be bothered from the air again this night and could now use its own advanced night fighting capabilities with impunity against the Atlantican ground forces.

This fictional account of battle in the near future is plausible with our current technology. The technology to pass target identification and designation to SHORAD fire units and have them slew to the target is currently being fielded with the Avenger Slew-to-Cue weapons system.[1] The Marine Corps has successfully tested a mounted AMRAAM system, and the Army's Air Defense Artillery School has scheduled a test of a beyond visual range identification (BVRID) system in December 1997. The HUMRAM or Divisional Air Defense Launcher, would mount the Air Force AIM-120 AMRAAM missile on a HMMWV

with a fire control system much like an Avenger, giving divisional air defense units the capability to counter enemy helicopter stand-off tactics out to 20 Kilometers. [2]

While technologically the Army's air defense community is making great strides in keeping pace with a perceived revolution in military affairs (RMA), doctrinally it is still adhering to its WWII requirement of positive visual identification of aircraft for SHORAD units before engagement.[3] This doctrinal requirement apparently arose from a paradigm of how SHORAD fire units operate that dates back to WWI, and a desire to prevent fratricide. The paradigm is based on the assumption that SHORAD units have no method to receive accurate electronic target identification or designation, or a capability to effectively engage targets beyond visual range. [4] The fielding of FAADC3I and the Slew-to-Cue Avenger systems, along with the current tests and studies of the vehicle mounted AMRAAM have made this assumption invalid. The current threat faced by SHORAD units may also make these assumptions disastrous. As military thinkers debate whether we are now in the midst of a RMA, the time has also come to question whether this visual identification requirement should be eliminated for those units technologically capable of BVRID engagements. This paper will attempt to answer that question, discuss reasons for the change, and address the issues that are necessary for such a change.

While there is not much printed material on the subject available today, there are several activities that are developing BVRID procedures for SHORAD units. This monograph will necessarily rely heavily upon interviews with the people who are actively engaged in these combat developments, and the results

of the tests conducted. It will also be necessary to review doctrinal publications and reports from field test agencies to gain an appreciation of the current threat faced by these units, our current doctrine and its implications, current SHORAD capabilities and combat developments, and the implications of a change to BVRID doctrine.

This monograph proposes that there is a need for change and that the need is threat based. The first chapter will examine the threat and what the current capabilities of that threat are. Next I will look at our SHORAD doctrine to examine its goals, why and how we arrived at this doctrine, what the assumptions are that it is based on, and how effectively it achieves its goals. From this point I will move to a discussion of new and emerging SHORAD systems, and how the capabilities of these systems may challenge the assumptions of current doctrine on BVRID. The following chapter will look at the implications and costs of a doctrinal change allowing BVRID engagements by SHORAD. Using this method of examining the threat, current doctrine, emerging systems, and analyzing the engagement implications and costs of doctrinal change, I will then present my conclusion on the need and feasibility of a change in current doctrine concerning BVRID.

Chapter 1

The Threat

The demise of the Warsaw Pact significantly reduced the threat of massed fixed wing aerial attacks on U.S. ground forces, but now our forces face a much more diversified and sophisticated threat from a multitude of aerial platforms. In April 1993, the Combined Arms Command at Fort Leavenworth published the most comprehensive threat air capabilities study since 1985. The study was based on post Cold War threats through 2005 and used Defense Intelligence Agency (DIA) approved sources. The study found that fixed-wing aircraft no longer constituted the principal air threat to ground forces, and that the main aerial threat to ground forces would come from unmanned aerodynamic vehicles (UAV), cruise missiles (CM), and helicopters.[5]

This chapter will focus on these three threats, not only because they are deemed to be the most likely threat to joint ground forces, but also because they present an extremely difficult problem for air defense units that rely on visual identification of targets. The proliferation of these systems is widespread, which means that both friend and foe may be using the same models. The speed and small profile of CMs and some UAVs increase the problem of visual identification. All of these threats have ever increasing stand-off capabilities. These features of the threat combine to make visual identification and engagement of these targets, before they can complete their missions, problematic for SHORAD. We will

examine each of these threats in turn and then see how visual identification doctrine fares against them.

Unmanned Aerodynamic Vehicles

> Unmanned aerodynamic vehicles (UAV) have emerged as a new, multi-faceted threat on the battlefield. Their ability to conduct reconnaissance, intelligence, surveillance, target acquisition (RISTA) and armed/attack operations can significantly disrupt the ground force commander's operational plan.[6]

The proliferation of these new systems is widespread. At least 46 countries now manufacture UAVs, with more than 150 different types produced outside the United States. In addition, the number and location of countries which import UAVs, including American models, ensure that U.S. forces may face them in any theater. One of the reasons for this proliferation is cost. UAVs are relatively inexpensive compared to modern fixed wing attack aircraft, which are at least multi-million dollar platforms.[7] This provides nations with severe budget limitations a type of poor man's airforce, by enhancing the armed forces' ability to communicate, conduct reconnaissance, and strike targets.[8]

UAVs can be used to perform a number of combat missions. They provide intelligence data for maneuver commanders, provide target acquisition for artillery, enhance communications capabilities, and can be used as attack platforms. The ability of these aircraft to fly low and slow, combined with a very small radar cross-section, makes them difficult to detect and track. With stand-off ranges varying greatly from 300 meters to 3000 meters, positive visual identification of these small vehicles at stand-off range is difficult at best.[9]

The trend for UAVs is continued growth as an alternative platform and increased capabilities. The successful employment of UAVs by Israel, and "during the Gulf War should ensure future market growth. Several Nations are developing and fielding antiradiation UAVs with the primary mission of attacking battlefield emitters."[10] Such a trend carries serious consequences for a U.S. Army which is becoming more dependent upon sophisticated communications systems. Also in development are UAVs with infrared attack systems, which can target armor vehicles, and ordnance delivery capabilities similar to more traditional attack aircraft. [11] The Threat Division of the Directorate of Combat Developments (DCD) at the US Army Air Defense Artillery School (USAADASCH) maintains that, "UAVs are becoming the most stressing aerial threat in the division area."[12]

Cruise Missiles

One of the most difficult aerial threats to defeat is the cruise missile. CMs come in a wide variety of "sizes, shapes, and with varying payloads, ranges and capabilities."[13] The range of CMs can be from 10 to 4000 kilometers and can be launched from land, sea, or air platforms. This stand-off range, combined with lower target signatures, as well as the capability to carry different payloads including weapons of mass destruction (WMD), make the CM a highly survivable and dangerous threat to ground force commanders.[14]

The success of CMs in the Gulf War, the spread of technology worldwide, and their relative cost effectiveness are spurring the proliferation of CMs

throughout the globe. As CMs become easier to use and the number of systems increases, the prospects for worldwide proliferation are high. The costs of the platforms may continue to decline as the free market in computer technology drives prices down. The guidance system is the heart of the cruise missile and directly affects its accuracy. With the ready availability of global positioning systems (GPS) the costs of a crude CM may fall as low as $10,000, making it available to almost any nation or group, and ensuring continued proliferation. Indeed, the number of land-attack cruise missiles (LACM) is expected to double in the next ten years.[15] One journalist claims that, "Right now you can build your own cruise missile with a Cessna, a hand held GPS navigator, a video camera, and some TNT."[16]

"The spectacular success of the U.S. Tomahawk land-attack cruise missile during Desert Storm dramatically illustrated the benefits of such systems, and aroused the interest of military leaders around the world."[17] Typically CMs are used for deep strikes on strategic or political targets, or suppression of enemy air defenses, but with WMD munitions they pose a significant threat to ground forces. The French are developing a ground attack version of the CM as a multi-mission, anti-runway, and anti-tank system. New terminal seekers can acquire a target and guide the missile through almost any type of reduced visibility including smoke, dust, rain, or fog. The low altitude and small size of CMs make detection, and especially visual identification of CMs extremely difficult. Further compounding the problem is the fact that CMs can approach their target from any direction. Currently Avenger gunners have almost no chance of successfully

engaging CMs without prior warning and slew-to-cue capability. Even with these capabilities the positive visual identification of a CM as hostile remains a significant problem for the gunner.[18]

Improvements in CMs through the year 2000 will only make them more lethal, accurate, and dangerous to corps and division targets. Improvements are being made in propulsion, guidance, warheads, and airframes. The improvements in guidance systems and seekers will allow for automatic target recognition and pinpoint accuracy. Radar cross sections will become significantly smaller by using advanced composite materials and airframe designs. This will make the missiles even harder to detect and track. There appears to be a trend toward shorter range missiles with submunitions that will be able to hit tactical moving targets. These capabilities will allow an adversary to strike targets the full depth of the battlefield.[19]

Helicopters

In the division area, helicopters are very likely the most dangerous air threat to armor and infantry units. Rotary wing (RW) aircraft currently exist in every potential theater that U.S. forces may be engaged, and they can be used in a multitude of roles from combat support to attack operations. Helicopters were among the first platforms used by Iraq in its invasion of Kuwait and U.S. Army Apache helicopters were used to knock out Iraqi air defense radars on the first night of the allied air campaign of Desert Storm.[20]

More than 14 countries produce military helicopters and more than twice that number are major importers. Currently over 150 nations possess helicopters to support military operations and the trend for continued proliferation shows no sign of slowing. The versatility of rotary wing aircraft to perform a wide variety of missions makes them an excellent choice for any nation looking for "more bang for the buck." Given $50 million dollars, an adversary could buy one fixed wing fighter, or four attack helicopters, or ten utility helicopters. Utility helicopters can easily be equipped with reconnaissance equipment or given an attack capability. As the cost of military equipment continues to increase, more and more nations will likely look to rotary wing aircraft as a cost effective means of employing air power in military operations. "In general, foreign military planning for the potential employment of the helicopter has assured the future of the platform for several decades." [21]

Vadim Krivosheyev, a Physicist at the Lebedev Physics Institute in Moscow predicts continued product improvement and proliferation of helicopters:

> According to the conclusion made in the analytical research World Makers of Military Helicopters released by the International Forecast Organisation in November 1992, helicopters have unique opportunities for further development. By the year 2000, 7,828 combat helicopters are expected to be sold at the world market at a price of $72 billion.[22]

The versatility of the helicopter's combat capability and the proliferation of so many similar models are the main reasons that it is so threatening to air defense forces. In any combat environment, U.S. forces may face French, Chinese, Russian, and even U.S. models as adversaries. China has models from three of these countries including the U.S. Blackhawk and the French Gazelle. The fact

that an adversary may fly the same aircraft as friendly forces makes positive visual target identification extremely difficult. Yet this fact makes correct identification enormously important in order to prevent fratricide.[23]

Helicopters have the capability to hover, use terrain masking, and nap of the earth (NOE) techniques which make them tough to target from the ground. Full night capabilities on several of the more sophisticated models further inhibit a SHORAD gunner's capability to engage a target using visual identification techniques. In addition, the stand-off range of the modern attack helicopter is increasing dramatically and so is the effectiveness of the armament it carries. This makes early engagement and early identification by SHORAD even more important.[24]

The Russian KA-50 Hokum is one of a growing number of attack helicopters that present a significant threat and tremendous challenge to American SHORAD units. The KA-50 and KA-52 helicopters have day and night capability and can carry armaments of increased range and lethality. The Hokum can carry up to 12 Vikhr-M anti-armor missiles. These laser beam riding weapons are extremely accurate and have a range of between 8-10 kilometers. They can also carry the At-X-16 anti-radiation missile with a range of up to 12 kilometers. The Mi-28 Havoc can carry a version of the AT-6 Spiral (M114 Shturm) with a range of 6-8 kilometers. The increased range of these missiles translates to a significant stand off capability. This capability is made all the more effective when these helicopters face an adversary whose doctrine forces SHORAD units to visually identify targets before engaging them.[25]

One of the major findings of the 1993 CAC study was that "armed and attack helicopters constitute the most widespread and capable air threats to ground forces in the close battle." The study further concluded that helicopter stand off capabilities would increase and that night operations would become common. With increased proliferation from both western nations and former Warsaw Pact countries, the probability of U.S. forces facing an adversary with a sophisticated rotary wing aviation capability, and possibly the same models as us, increases also.[26]

Summary

As a result of limiting engagements to visual target identification range, threat helicopters can stand off, out of range of friendly air defense, and destroy ground targets. At night this disparity is more pronounced as visual target recognition range decreases. Hokum helicopters carrying the Vikhr-M missile at night can hover 4 to 10 kilometers away from friendly SHORAD units with impunity. Unless a commander is willing to push his SHORAD units forward of his own troops, he has no organic capability to counter this threat. SHORAD also has difficulty engaging low profile targets such as CMs and some UAVs before these units can carry out their missions. UAVs conducting RISTA can fly flight patterns that put them outside the visual identification range of Avengers and Linebackers. CMs targeting critical nodes in the division area can present a tremendous challenge to SHORAD units because of their low profile. Early and multiple engagements of CMs are necessary for SHORAD units to prevent these

attack aircraft from delivering their payload. By requiring visual identification of targets, current doctrine makes the successful defeat of these weapons by SHORAD very difficult.[27]

Chapter 2

SHORAD Doctrine

Before one changes doctrine, it is prudent to examine that doctrine to see if it needs to be changed. Doctrine should be evaluated based on its ability to accomplish its objectives against the threat, and the validity of any of its assumptions. Two of the objectives of current SHORAD doctrine are to prevent fratricide and facilitate early engagement of targets before they can complete their missions. Two pertinent "assumptions", or paradigms, that I believe are inherent in this doctrine are that SHORAD units can not fire beyond visual identification range, and that SHORAD units have no method of receiving or making accurate target identification other than visually. This chapter will present a historical review of the development of SHORAD doctrine to show how these "assumptions" developed and shaped doctrine, and then will examine how well this doctrine meets its objectives against the current threat.[28]

Historical Development

During World War I, armies modified their field guns and machine guns so that they could fire in the air to protect ground troops and installations against the new threat presented by the combat airplane. Hastily organized under the Coast Artillery, anti-aircraft artillery (AAA) units were fielded for the American Expeditionary Force in 1917. The early American air defenders borrowed not only weapons, but doctrine from the French who had been conducting anti-aircraft

operations since 1914. The AAA School instructed both officers and soldiers from the Coast Artillery on the new doctrine, including the need for proper aircraft identification.[29]

Because of a lack of radar systems and the generally short range of the anti-aircraft guns of the time, aircraft identification would necessarily be visual, besides the gunners had to see their target before they could aim at it. Barrage fire, developed so that AAA units could defend against night attacks, was the one case where gunners were allowed to fire without visually identifying their target. Several methods were used to identify friend from foe, including aircraft markings, physical characteristics, the activity the aircraft was engaged in, and a rudimentary procedure for dropping colored flares. All of these methods required the gunner to see the aircraft, and even then, friendly aircraft were still shot down by friendly AAA and other ground units.[30]

During the inter-war years, improvements in aircraft and anti-aircraft armaments grew at a great pace. By 1940, AAA units were classified as either heavy anti-aircraft (HAA) or light anti-aircraft (LAA) based on the capabilities of the gun systems. The twin developments of radio and radar not only provided early warning to the AAA gunners, but also provided a means of command and control, tracking and identification of aircraft. Improvements in aircraft, especially high altitude bombers would force HAA air defenders to use this technology to engage at ranges and in conditions beyond which gunners could accurately visually identify their target. [31]

Technology had not progressed to the point where this system could be adopted by LAA units, the predecessors of today's SHORAD units. Early tracking radars and command and control centers were cumbersome pieces of equipment that lacked the mobility necessary to operate with LAA units. The nature of the threat and the terrain in which the LAA units operated severely restricted radar effectiveness. Aircraft flying at low altitudes could not be continuously tracked because of blind spots in the radar coverage. In addition, LAA units did not have a capability to receive accurate target identification data from an outside source nor the ability to perform this task organically by any means other than visual.[32]

The main method of engaging a target for LAA was shooting over open sights with the help of predictors and deflectors to aid in elevation and lead angle. The radars that did operate near these units were primarily used to provide early warning. Since IFF was merely an aid in identifying targets, and expensive, there was no effort to equip these AAA units with this technology in any significant numbers. The method of identifying hostile targets remained visual. This was not a significant handicap for the gunner, since the range of his system would not allow him to hit a target he could not see.[33]

By the time of the Korean War not much had changed for AAA. U.S. dominance of the airspace relegated most AAA units to ground attack operations, and any impetus to change the way of identifying enemy aircraft never materialized. In addition, the weapon systems used were not much more advanced than those of WWII. There was no perceived need to identify targets beyond visual range for AAA.[34]

In Vietnam the story was very much the same. The new 20mm Vulcan proved itself very effective in the ground attack mode. The Vulcan had a range radar with the gun to help in fire direction, but there was still no method for passing target identification and designation to the gun. The development in the 1950's and 60's, of extended range surface-to-air missiles (SAM) with much improved radars and command and control systems, forced changes to the methods of electronic and procedural identification of aircraft as friendly or hostile. But these new procedures only applied to high and medium altitude SAMs. Again the lack of a threat and the relatively short range of the Vulcan ensured that the question of SHORAD units engaging beyond visual range did not become an issue.[35]

By the time of the Gulf War, SHORAD weapon systems had improved dramatically with ranges which now reached at least 5 kilometers. This was more than the range at which a gunner could positively identify an aircraft with the naked eye, and at the outer limits of his capability if his system was equipped with Forward Looking Infrared (FLIR). There was no SHORAD command and control systems that would allow the passage of accurate target identification and designation to the fire unit level, and the requirement for positive visual identification remained. By the early 90's, the Army was beginning to develop an advanced SHORAD command and control system, FAADC2I, but it would be fielded mainly as an aid to early warning/cueing and air defense planning. Again, in the Gulf, as it had in Korea and Vietnam, the paucity of a significant air threat failed to provide the necessary impetus to change the visual identification

requirement for SHORAD, even though the weapons could now shoot farther than a gunner could accurately identify aircraft. The potential conflict between the "assumption" that SHORAD could not shoot farther than it could see, and the increased range of missiles was ameliorated by the FLIR, although, even in 1997, many SHORAD units still do not have FLIR. [36]

This survey of the evolution of SHORAD doctrine highlights the genesis and maturation of the "assumptions" that SHORAD units can not fire beyond visual identification range and that they have no method of receiving or making accurate target identification other than visually. These assumptions have endured because they are rooted in historical fact, but changing technologies have begun to challenge their validity, as we will see in a subsequent chapter. The survey also brings out another salient feature of doctrine development, and that is the role of the threat. Furthermore, if the doctrine is effective, that is if it is capable of achieving its objectives against the threat, then there is no pressing need to change it. So the last task of this chapter is to evaluate the current doctrine's capability to achieve its objectives.

Achievement of Objectives

The prevention of fratricide and early engagement of enemy air threats are two objectives or goals for air defense doctrine that are central to the problem of BVRID engagements. The importance of these two objectives to BVRID is self-evident. If fratricide was not a concern, there would be no need to moderate a

desire to fire at targets beyond visual identification range. Similarly if early engagement was irrelevant to the task of preventing an enemy air platform from delivering its ordnance on friendly forces, then there would be no reason or impetus to try to engage beyond visual range.

In the past there was little friction between these two goals, but the current threat has now presented us with a doctrinal problem. With stand-off capabilities that exceed the range at which visual identification is possible, the threat has created a situation that brings these two objectives into conflict under the current doctrine. The dilemma can be summed up this way. If SHORAD units attempt to fire beyond visual recognition range to achieve early engagement, the popular opinion is that they increase the risk of fratricide. If they do not engage until the target can be visually identified in order to prevent fratricide, they reduce the capability of achieving early engagement.[37]

Incidents of fratricide against friendly aircraft have been a problem since WWI, reaching a peak in WWII. Since that time no incidents have been attributed to SHORAD units, but friendly aircraft have been attacked by other units using visual identification. Most often these incidents were the result of mis-identification of the target for one reason or another, leading the military to an active search for the best means of limiting or eliminating these incidents. The development of new technology and procedures for identification has moved this debate to one of technological/procedural identification versus visual identification as the best means of preventing aircraft fratricide.[38]

Proponents of visual recognition believe that allowing engagements at longer ranges and BVRID would increase the number of fratricide incidents, while the other side feels that allowing technology to identify the target will reduce the number of incidents. In reality, the multitude of factors involved in the incidents, and lack of incidents of fratricide, does not provide a clear answer. Both technological and visual means have failed at times. Even a combination of the two methods is not fool proof, as was demonstrated in 1995, when the Air Force shot down two friendly Blackhawks that had been misidentified both electronically and visually. And certainly the lack of SHORAD incidents since WWII is as much a result of the lack of a threat, as it is a result of visual identification requirements. While there is not enough evidence, and too many factors involved, to suggest the visual identification requirement has reduced fratricide by SHORAD units, this requirement has not caused any SHORAD induced fratricides since WWII, and in that light has been successful, or at least not unsuccessful, in achieving its goal. [39]

This brings us to the problem of how this requirement impacts on the goal of early engagement of enemy air threats. The threat, as we have seen, is now characterized by increasing stand off ranges (8-12 kilometers for helicopters and farther for RISTA UAVs, and CMs), lower target profiles and flight paths, high speed, and the capability of CMs to attack from virtually any direction. Our own SHORAD capabilities are currently limited to 5 kilometers in daylight with FLIR equipped units and down to 2 kilometers in darkness for the same unit. This limitation is more a product of our doctrine than weapons capabilities since our

systems are capable now of firing at least 5 kilometers in all weather and visibility conditions.

If FLIR equipped SHORAD units are operating with front line troops, the greatest range at which they could engage a target is 5 kilometers across the FLOT. Enemy aerial RISTA and attack platforms with ranges of 8 kilometers or greater can sit 3 kilometers beyond our ability to engage them and complete their missions in relative safety. During the '97 Prairie Warrior Exercise at Ft. Leavenworth, OPFOR aviation exploited just such a tactic at night with devastating results for friendly maneuver forces. Because of doctrinal limitations SHORAD units could not fire at the targets beyond 2 kilometers even though the targets could be acquired and tracked, but not visually identified, beyond that range. From this example, and an analysis of the delta between enemy stand off and SHORAD engagement ranges, it appears that the requirement for visual identification prevents the achievement of early engagement, at least along the FLOT.[40]

Without an early engagement capability against the threats described in Chapter 1, ground force commanders can suffer devastating results. Enemy UAVs can track friendly movement at will, and interdict it if desired. Enemy helicopters will be able to smash assault formations long before they reach their objectives and prevent the concentration of friendly combat power at decisive points. And hostile CMs with WMD warheads can virtually stop a division attack in its tracks. Against these targets there is no significant help from friendly Air Force units once the enemy is airborne. The Joint Force Air Component

Commander (JFACC) must allocate his aircraft to support the Joint Force Commander's (JFC) target priorities, and gain and maintain the freedom to do that through air superiority. As a result, the JFACC will generally be focused on targets other than UAVs, CMs, and helicopters.[41]

Summary

In this chapter we have reviewed the development of the assumptions upon which SHORAD visual identification doctrine is based. We have also looked at this doctrine's capability to meet two of its stated objectives; preventing fratricide and providing for early engagement. While it appears that this doctrine has been relatively successful in preventing fratricide, it is evident that it has some significant shortcomings in providing for early engagement. In the next chapter we will examine the capabilities of new and emerging SHORAD systems which make a discussion of BVRID pertinent, and raise questions as to the validity of our doctrinal assumptions.

Chapter 3

SHORAD Combat Developments

New SHORAD systems are being examined by the combat development community worldwide. Most are based on existing technology and missiles, but some will employ radically different approaches. As stated earlier, these new and emerging systems may challenge the validity of the assumptions upon which our doctrine is based. In this chapter I will restrict our discussion to those new, and near future systems whose capabilities most directly effect the question of BVRID engagements. That is those that provide either increased weapon range, increased acquisition range, longer range identification capabilities, or a combination of these improvements, and can integrate, or help integrate, those capabilities at the fire unit. In the final part of this chapter I will discuss how these systems may challenge the validity of our doctrinal assumptions.

The current U.S. SHORAD air defense structure includes Avenger, Avenger Slew-to-Cue (STC), Bradley Stinger Fighting Vehicle (BSFV), Linebacker, man portable air defense systems (MANPADS), and the FAADC2I system. Although most fielded U.S. systems are an outgrowth of the Cold War, some (Linebacker, Avenger STC, and FAADC2I) were designed or upgraded to face the new emerging threat. All of these weapon systems are based on the Stinger missile, but many of the new weapons will employ longer range missiles such as the AMRAAM. Considering the criteria, my discussion will cover the

Stinger based systems, longer range SHORAD systems, counter air directed energy weapon systems (CADEWS), and finally FAADC2I.

Stinger Systems

Designed to counter the cold war air threat to maneuver forces in Europe, the Stinger missile is a proven short range air defense weapon. It is man-portable, although a bit bulky and heavy. In the MANPADS configuration, it is a shoulder fired weapon with optical sights. The missile uses passive infrared (IR) homing to guide itself to the target, and the range is approximately 5 kilometers. Current block improvements to the system will give it improved lethality and dramatically increased range against cruise missiles, UAVs, targets in clutter, and a full night capability (Block II). These improvements mean that the weapon is now capable of engaging aircraft beyond the range at which visual ID is possible, especially at night. [42]

Avenger and Avenger STC employ the Stinger as the main air defense weapon, but this system has some greatly enhanced capabilities over MANPADS. It is equipped with a Forward Looking Infrared (FLIR) system, which increases the gunner's acquisition range of targets, and increases the range at which the gunner can correctly identify a target. The standard vehicle mounted launcher (SVML) is controlled by a gunner in the turret who acquires and tracks targets on a display connected to the FLIR. Equipped with early versions of the FLIR, a gunner could detect a fixed wing target visually at more than 11 kilometers, and a helicopter at greater than 8 kilometers in good visibility. He

could correctly identify these aircraft at almost 7 kilometers for fixed wing, and just over 5 kilometers for helicopters. UAVs and CMs were not included in this early target acquisition/identification test, but their low profile will make the identification ranges shorter. Current improvements to the FLIR improve the positive Identification capability by 1.5 times.[43]

The STC upgrade allows the Avenger to accept track data from an outside sensor, such as FAADC2I, and automatically slews the turret in azimuth and elevation so that the target is placed in the gunner's field of view. This not only helps in acquiring small profile targets such as UAVs and CMs, but increases the range at which this can occur. What is more important, target information and identification can be passed from the outside source directly to the gunner's display. With this information he could engage a target, already identified as hostile by an outside source, well before it was in range for him to visually identify it himself. [44]

The Linebacker is based upon upgrades to the Bradley Stinger Fighting Vehicle, particularly a SVML similar to the Avenger's controlled by the turret. The TOW sight has been replaced with a FLIR giving the system the same target acquisition and identification capability as AVENGER. According to tests conducted by the TRADOC Systems Manager (TSM) SHORAD, the improvements to Linebacker so far, provide a 140% increase in kill capability, full night capability, and the ability to detect and engage CMs and UAVs. The addition of STC capability under current and planned upgrades will exploit these

capabilities further, and make BVRID engagements through outside source identification of the target possible.[45]

All Stinger based systems possess an electronic IFF. Avenger and Linebacker can also be linked digitally to FAADC2I for target information. Current improvements to the Linebacker and Avenger include: STC capability and integration of FAADC2I while on the move for Linebacker; improved capability versus low observable targets (CM, UAV); engagements at the maximum kinematic range of the missile; increased detection range; and improved FLIR/TV optics for night operations. In June 1996, both Avenger and Linebacker STC systems engaged and destroyed cruise missile targets under severe conditions. With improvements to the missile, the delta between threat stand off capabilities and STINGER missile capabilities is significantly lowered. Both of these systems now have the capability to engage targets BVRID range, and to receive target identification data from outside sources. [46]

Longer Range SHORAD Missiles

Several nations, including the U.S., are looking at new SHORAD weapons with longer ranges. These new missiles ". . . do not fall into any precisely defined category, although they generally have a maximum range of at least 15 kilometer." Norway is deploying a new system based on the AMRAAM missile and the Swedish Army plans to deploy a missile system with about a 15 kilometer range. In addition, the Swedish firm Bofors is developing a laser beam-riding SHORAD missile that will have a range of 10 kilometers and a ceiling of

about 7 kilometers.[47] All of these systems can shoot farther than visual identification range.

In the U.S., both the U.S. Army Missile Command (MICOM), and the Army's Air Defense School's Directorate of Combat Developments (DCD) have been conducting their own investigations of longer range missiles for the past few years. The AIM 120 AMRAAM appears to be the weapon of choice for both of these agencies. The missile, with a range of approximately 20 kilometers, has an active seeker that allows it to find the designated target and attack it. [48]

The "HumRam" or Divisional Air Defense Launcher, which mounts the AMRAAM on a HMMWV, has been successfully tested by MICOM and the U.S. Marine Corps. The system successfully engaged head on targets at ranges of 19.3 kilometers and 17 kilometers (all BVRID range) during the Marine Corps test. DCD at Fort Bliss will conduct its test of the system in December 1997. The missile is fired ". . . to a point in space where it goes active and attacks the target." Virtually all the components of the system are available off the shelf, and it would give a division commander the capability to influence the airspace over his entire division. What is more important, it gives divisional SHORAD units the capability to effectively counter threat stand off ranges, and actually create a delta in those ranges that is favorable to us against helicopters and many UAVs. To take advantage of this capability, the units would have to engage BVRID range. [49]

CADEWS

CADEWS is a system under study by DCD that will use directed energy technologies such as lasers or high-power microwaves, in a mobile surface-to-air weapon system. Used as a SHORAD system it will be capable of destroying threat targets at a range of at least 8-10 kilometers. It will also have the capability to disrupt sensors on threat platforms at ranges up to 100 kilometers. The plans for CADEWS include the capability to fully integrate with available sensor and C2I networks so that it can receive the necessary target data for BVRID engagements. This system will close the delta created by threat stand off ranges for attack platforms, and provide a capability to overcome the delta created by threat RISTA stand off ranges. [50]

FAADC2I

One of the most dramatic developments in SHORAD air defense is the development of the FAADC2I system. This system integrates target detection and identification from AWACS, HIMAD, and netted sensors within the division. It will display the air picture for the entire divisional area. FAADC2I can use SINGCARS or EPLRS which will allow it to pass digital information to fire units without the need for line of sight. The non line of sight capability to pass target information to fire units overcomes the inability of SHORAD to continuously receive accurate target data while maneuvering with forward forces that has plagued these systems since WWII.[51]

With FAADC2I, the SHORAD air defense unit is able to integrate with all the other airspace users and share a common air picture. The air track display capability of the FAADC2I is tremendous. The system at the battalion level is capable of displaying 210 tracks, 64 tracks at the battery level, and 16 tracks at the fire unit. The track information includes data about the target, designation as hostile, friendly, or unknown, and where the target information originated. [52]

One of the most useful features of FAADC2I is the ability to provide early warning to fire units of targets that are masked from their field of view. In addition the system can cue fire units to targets that are beyond their visual range and even slew the system so that the missile is pointed at the target. This allows fire units to lock on to a target long before they can see it and increases the range at which the target can be engaged. This technology works, and was successfully demonstrated in the Avenger STC engagements of CMs as stated earlier.[53] This ability to continuously pass accurate target information, and cue or slew SHORAD systems to targets beyond visual range, is a capability that no SHORAD system had until now. It provides the data required by SHORAD units to engage an identified hostile track BVRID range.[54]

Implications for Doctrinal Assumptions

As stated earlier, our current doctrine regulating SHORAD engagements grew out of the assumptions that the range of SHORAD weapons was not farther than visual recognition range, and that these units had no means of receiving or making accurate target identification other than visually. The recent

developments in SHORAD missiles, weapons systems, and C2I systems certainly challenge these assumptions. STINGER missiles with block improvements can now fire beyond 5 kilometers. AMRAAM missiles and directed energy weapons can do the same. System improvements on the weapon systems themselves and their capability to integrate with sophisticated sensors and C2I systems such as FAADC2I, can provide accurate target identification beyond visual range right at the gunner's console. STC even brings with it the possibility of firing on targets at extended ranges which until now, could not have been visually detected and acquired, and certainly could not have been correctly identified.

The bottom line is that SHORAD units now have, and in the near future will have, increased capability to fire beyond visual range, and to obtain accurate target identification data by means other than visual. These capabilities, with current technology, make invalid the assumptions upon which SHORAD visual engagement doctrine is based and give cause for a reevaluation of that doctrine.

Chapter 4

Implications of a BVRID Doctrine

In this chapter we will explore the implications of changing SHORAD doctrine to allow BVRID engagements. Our discussion will focus on three areas that are critical to any decision to adopt a new doctrine. First we will examine whether BVRID engagements will help SHORAD counter the threats that we discussed in chapter two. Second, we will see if a BVRID doctrine is capable of meeting the stated objectives of our current doctrine. Finally, we will look at the cost involved in changing our doctrine in terms of airspace control rules of engagement (ROE) and the need for joint inclusion of the doctrine, and in terms of hardware and software requirements.

Countering the Threat

The driving force for any doctrinal change should be the ability of new doctrine to counter the capabilities of the threat. As discussed in chapter two, the threat today consists of UAVs, CMs and helicopters. All of these threats have characteristics which present problems for SHORAD to counter.

The problems presented by UAVs are low target profile and stand off range. FAADC2I and STC technology integrate a multitude of sensors including those, such as SENTINEL, that have a capability to acquire these low signature targets. Integrating the acquisition and identification capabilities of the sensors and STC on the weapon platform, allows the gunner to "lock on" small signature

targets, at extreme ranges, that they would otherwise be unable to acquire by visual means. The integration of the systems also means that acquisition range is determined by the limit of the sensor's capabilities rather than the weapon's organic acquisition capabilities. With sensors whose ranges vary from 40 km to 100s km, no UAV is capable of standing off out of the acquisition range of such an integrated system.[55]

UAVs with RISTA missions directed against front line troops can stand off between 3 to 6 kms. The range of the new SHORAD weapons, up to 20 kms for kills and 100 kms for disruptive effects against sensors, negates this stand off capability if allowed to operate under BVRID doctrine. In fact, the delta between the engagement capabilities of the new SHORAD systems and threat UAVs is in favor of SHORAD.[56]

As stated earlier, CMs are one of the most difficult aerial threats to defeat by SHORAD. Like UAVs their small profile and radar cross section present significant problems. In addition, their low attack profile, ranging from 50 meters to 3000 meters, makes visual detection and acquisition problematic. Using the full capabilities of FAADC2I integration with STC allows acquisition of these systems at long range much as it does against UAVs. More importantly, the new systems and BVRID doctrine will allow SHORAD systems to engage CMs at extended ranges, facilitating multiple engagements as the CM approaches its target, and increasing the odds of a lethal hit. This capability to engage at long range allows SHORAD to destroy CMs carrying WMD while they are over enemy territory, further increasing the ability to counter this threat.[57]

The capabilities of the new SHORAD systems against helicopters are much the same. The integration of FAADC2I, STC technology, and longer range weapons negates, and in some cases reverses, the stand off capabilities of this deadly threat. If allowed to follow BVRID ROE, SHORAD units on the front line would be able to engage and destroy sophisticated enemy attack helicopters as they approached their attack positions, long before they could launch their ordnance at friendly forces.

The exploitation of the new SHORAD systems' capabilities is contingent upon the adoption of BVRID doctrine. Armed with that doctrine, the new SHORAD systems, fully integrated with outside sensors, will be able to acquire and engage previously identified targets at ranges that negate, or at least lessen, the advantages currently enjoyed by these threats.

The ability to counter the threat is only one of the criteria that doctrine must be evaluated against. The ability to meet the objectives of our doctrine are equally important. In this case the two objectives deemed most important are early engagement and the prevention of fratricide. The next section will evaluate BVRID doctrine's capability to meet these two doctrinal objectives.

Meeting the Objectives

The ability of BVRID doctrine to meet the objective of early engagement is self evident from the preceding section. BVRID doctrine allows the systems to exploit their full capabilities of increased range in acquisition, identification, and

engagement. The ability to meet the objective of preventing fratricide is not so clear, and requires further examination.

The debate over the best method of preventing fratricide for SHORAD units has been ongoing, and is best characterized as one between visual and technological/procedural identification methods. The requirement for technological/procedural identification methods is inherent in BVRID doctrine, so we will restrict our discussion to this method and see if and how it can prevent fratricide.[58]

An analysis of SHORAD units by the Army Human Engineering Lab focused on the amount of information that SHORAD gunners had to process for an engagement. The study found that the information requirements of SHORAD were greater than other combat elements, partly due to the requirement for visual identification. The study was concerned that the information could result in information overload in which the requirements were greater than the soldier's capability to process the information. This information overload could result in more errors, or an increase in time required to process information which could then lead to degraded performance to unacceptable levels. One way to reduce the overload of information is to provide reliable track data.[59] BVRID doctrine which incorporates the abilities of FAADC2I does this.

The report also found that the ability to process information varied greatly from one individual to another. If the information was processed by several sources then the chances of errors should be reduced.[60] BVRID doctrine relies on a multitude of sources for identification information. This system will give

redundancy to the identification process, as each echelon would be able to correct a mistaken hostile identification. The chance that all of the echelons in the communication network will make the same identification mistake is much less likely than if we rely on the eyesight of one soldier in combat.

Using identification through FAADC2I allows more time to evaluate the target reducing some of the pressures which result in information overload. The extra time will allow C2 personnel to more fully evaluate all of the characteristics of the track, including those that are not discernible by the gunner. In addition to IFF responses, the target can now be evaluated by its adherence to friendly airspace control measures, correlation to known friendly missions on the air tasking order (ATO), hostile activities along the full length of its route, evasive maneuvers, and its point of origin. The last point is extremely significant for if a target can be seen taking off from an enemy airfield "few would argue with the assumption that it is an enemy."[61]

Given that HIMAD and Air Force units must rely on this information for the employment of their long range missiles, there is no reason that SHORAD units should not be able to use the same information, from the same sources for target identification. Another benefit of this method of identification is the expected capability of these technological systems to incorporate the various other emerging combat identification systems into their own. The incorporation of all of these sensor and combat identification systems and techniques to provide target identification for a SHORAD gunner via FAADC2I, should increase the probability

of correct identification over current methods, and meet the objective of preventing fratricide.[62]

Costs of Changing Doctrine

Any changes in doctrine must finally be evaluated against the costs of making that change. The cost could be as small as having a word deleted from a manual, or it could require the development of new equipment and adjustment to other procedures and doctrines. The two areas that readily appear to have costs for the implementation of BVRID doctrine are costs in changing current joint procedures and shortfalls in hardware and software.

Currently the only Joint or Army doctrinal manual that specifies the use of visual identification for SHORAD is FM 44-43. The requirement can also be found in a CINC's ROE. The actual cost of changing one manual and changing ROEs is not very high. As we have discovered, doing so may well reduce the risk of fratricide and it certainly should not increase that risk. The real difficulty will be getting those who are accustomed to the old way of doing business to accept the new ideas. Area Air Defense Commanders (AADC), who are usually Air Force Component Commanders, and who recommend the ROEs for air defense, may be hesitant to allow Army SHORAD units to engage without visual verification of their targets. A full appreciation of the benefits and reduced risks of such a change may help to allay those fears. [63]

In addition, airspace control measures for the theater will have to consider the impact of SHORAD BVRID. The actual impact should be small. Airspace

control measures have taken into account the capabilities of HIMAD units for years, and the procedures for HIMAD and SHORAD BVRID are very similar. The planning of missile engagement zones (MEZ) will have to consider a new array of systems in the division area with greatly increased ranges, but FAADC2I capabilities to receive target identification information from Air Force sources should reduce any friction between air space users. In reality there is no significant cost for incorporating BVRID into ROEs.[64]

The greater cost for changing the doctrine is the hardware and software requirements to make the system work. A significant problem that impacts this area, is the ability of a SHORAD weapon system to correlate the on board information about a target with the information coming from outside sources. In other words, how does the gunner know that the target he is locked on is the target an outside source has identified as hostile? Accurate location data for the firing unit and the target are necessary and aerodynamic factors of the threat need to be resolved before proper correlation can take place. Continued development of this issue is required, but a solution should be available in the form of software and off the shelf hardware.[65]

In line with this concern, the Army will conduct a series of experiments which directly involve BVRID concerns. "Live Experiment II" in December 1997 will explore the feasibility of BVRID and provide insights into how to solve the target correlation issue. The experiment will use an array of sensors and the FAADC2I system to provide target information to SHORAD fire units, including longer range missile systems. The results of the experiment will be used validate

the concept, and to further implement the necessary software and hardware improvements.[66]

The final cost of implementing BVRID is the lack of sufficient equipment. Communications equipment is in high demand, and BVRID requires a large amount of digital communications capabilities to make the necessary data links between sensors, C2 platforms, and the fire unit. STC is scarce and very few fire units presently have this capability. The longer range systems are not yet beyond the prototype stage. Considering current funding constraints it is unlikely that a large portion of our SHORAD force will be able to take advantage of BVRID in the near future. Although funding puts a significant restraint on the full implementation of BVRID, the cost for adopting the doctrine for those units that are BVRID capable should be very small.[67]

Summary

This monograph proposes a threat based SHORAD engagement doctrine that leverages new weapons systems and technologies to achieve doctrinal goals, and breaks historical paradigms that are based on invalid assumptions. New doctrine must consider more than just new capabilities, it must also be driven by the threat. As we have seen the threat that U.S. forces are likely to encounter in the next 10 to 15 years has a significant air capability to disrupt our operations. Even those nations, or entities with no conventional air force, can inflict significant damage through the use of a "poor man's air force." This threat is characterized by increasing stand off ranges, low target profiles, and the capability to perform both attack and RISTA missions.

Our current doctrine is based on assumptions which grew from a historical paradigm of the capabilities of SHORAD to identify and engage targets. While this doctrine has been successful in preventing fratricide, it is unable to achieve early engagement against the postulated threat. This leaves our forward maneuver units increasingly vulnerable to air attack, and provides the impetus for a reevaluation of that doctrine.

The family of emerging SHORAD systems that includes weapon, sensor, and C2I systems invalidate the assumptions of current doctrine. These new systems provide capabilities that are a quantum jump from those that current doctrine is based on. The new SHORAD systems not only provide the capability to fire beyond visual range, but the integration of the systems provides an

effective means of identifying targets and passing that information to the shooters. These new capabilities, which go to the heart of current doctrinal assumptions, should be sufficient cause for a doctrinal reevaluation.

The implications of adopting a BVRID doctrine are impressive. BVRID will give us the capability to effectively counter the new threat platforms. Unlike current doctrine, BVRID allows us to achieve our objectives of preventing fratricide and early engagement. The costs of implementing BVRID are negligible. The real cost is for fielding BVRID capable systems. Funding shortfalls prevent fielding in large numbers for the near future, but that is not significantly different from our capability to field any other new weapon system. For the foreseeable future, many SHORAD units will continue to rely on visual identification because of a lack of capable equipment.

Faced with a new threat and armed with significant weapon systems improvements, the time has come to redesign current doctrine. BVRID doctrine will not eliminate the need for visual identification for those units incapable of leveraging BVRID technology, so visual identification will remain as a valid means of identifying a target. But for those units that can shoot beyond visual identification range, and can receive accurate target information from outside sources, and correlate this information at the fire unit, BVRID doctrine should be the norm.

ENDNOTES

[1] Thomas Flynn, LTC, (Director of Operations, Air Defense Battle Lab, Directorate of Combat Developments, United States Army Air Defense Artillery School, Fort Bliss, Texas), telephone interview by author, Fort Leavenworth, Ks, 4 September 1997.

[2] Kathleen Gainey, CPT, (Project Officer, Air Defense Battle Lab, Directorate of Combat Developments, United States Army Air Defense Artillery School, Fort Bliss, Texas), telephone interview by author, Fort Leavenworth, Ks, 4 September 1997.

[3] U.S. Army, *Field Manual 44-43, Bradley Stinger Fighting Vehicle Platoon and Squad Operations,* (Washington D.C.: U.S. Government Printing Office, 1995), 2-12.

[4] Apparently no documents exist which detail why or when this requirement was written into Army doctrine. Pat Rhodes, Historian, U.S. Army Air Defense School and Fort Bliss, says she can find no record of a discussion of the requirement in any of the inter-service agreements including the Key West Agreement in the 1950's which delineated most the air defense responsibilities and procedures between the Army, Air Force, and Navy. The only reference for the requirement the author or the Air Defense Lab has found is the reference in the current FM 44-43. Based on this, the general consensus among the author, Ms. Rhodes, and the Air Defense Lab is that the requirement is there because SHORAD units historically, have not been able to physically engage targets they could not visually acquire, and there have never been any fire control/target designation/target identification systems available for SHORAD fire units.

[5] U.S. Army, Combined Arms Command (CAC)-Threat Directorate, *Threat Air Capabilities Study (U)* (Fort Leavenworth, Ks, 1993), quoted in U.S. Army, U.S. Army Air Defense Artillery School (USAADASCH), Combined Arms and Tactics Department (CATD), *CGSC Branch Specific Training 1997* (Fort Bliss, Tx, 1997), Tab A, 11; The Joint Chiefs of Staff, *Joint Pub,3-01.2,Joint Doctrine For Theater Counterair Operations* (Washington, D.C., 1986), 14; and U.S. Army, USAADASCH, CATD, *Air Defense Operations Review for Prairie Warrior '97, (Read Ahead Packet),* (Fort Bliss, Tx, 1996), 1-5.

[6] U.S. Army, *Read Ahead Packet,* 2.

[7] U.S. Army, USAADASCH, *FY 98 Air and Missile Defense Master Plan,* (Fort Bliss, Tx, 1997), 2-7, 2-8.

[8] U.S. Army, USAADASCH, CATD, *CGSC Branch Specific Training 1996,* (Fort Bliss, Tx, 1996),Tab A, 15.

[9] Ibid., Tab A, pp 13-17; idem, *Read Ahead Packet,* 2-3.

[10] U.S. Army, *Branch Training 1996,* Tab A, 14.

[11] Ibid.

[12] U.S. Army, *Branch Training 1997,* Tab B, 10.

[13] U.S. Army, *Branch Training 1996,* Tab A, 20.

[14] U.S. Army, *Read Ahead Packet,* 3; idem, *Branch Training 1997,* Tab B, 11.

[15] U.S. Army, *Read Ahead Packet,* 3; idem, *Branch Training 1997,* Tab B, 12; idem, *Branch Training 1996,* Tab A, 22-24; and idem, *FY 98 Air and Missile Defense Master Plan,* 2-6.

[16] "Cruise Missiles Cheaper Than Cars", adapted extract from the American magazine *Liberty* (Nov. '94), monitored for the Institute by Roger Knights, Institute for Social Inventions, The Global Ideas Bank, [on-line] ; available from http:// www.newciv.org/worldtrans/BOV/BI/BI-267.html; Internet; accessed 30 October 1997.

[17] U.S. Army, *Branch Training 1996,* Tab A, 20.

[18] Flynn, interview; U.S. Army, *Branch Training 1996,* Tab A, 20-24.

[19] U.S. Army, *Branch Training 1996,* Tab A, 24.

[20] James Blackwell, *Thunder in the Desert, The Strategy and Tactics of the Persian Gulf War,* (New York: Bantam Books, 1991), xxii-xxiv; Paul Jackson, editor-in-chief, *Jane's All the World's Aircraft, 1996-97,* (Alexandria, Va.: Jane's Information Group Inc., 1997), 375-376; and U.S. Army, *FM 44-43,* 3-2.

[21] U.S. Army, *FM 44-43,* 3-2; idem, *Branch Training 1996,* Tab A, 8-9; idem, *Read Ahead Packet,* 3-4; Jeremy Parkin, "BUCHair Helicopter Databases- Civil and Military", (BUCHair UK Ltd) [on-line]; available from http:// www.buchair.rotor.com /heli-db.htm; Internet; accessed 1November 1997; and U.S. Army, USAADSCH, CATD, "How to Fight Air Defense in Force XXI" (briefing), (Fort Bliss, Tx, September 1997), 4.

[22] Vadim Krivosheyev, "Watson's Military Page," [on-line] available from http:// canopus.lpi.msk.su/~watson/ka50/ka50story5.html; Internet; accessed 1 November 1997.

[23] Hui Tong, "Chinese Military Aviation Home Page," [on-line] available from http:// www.concentric.net/~jetfight/Z-8_Z-9_Z-11.htm,and http:// www.concentric.net/~jetfight/Mi-17_SA-342_S-70.htm; Internet; accessed on 1 November 1997; and U.S. Army, *Branch Training 1996,* Tab A, 7.

[24] Jackson, *Jane's All the World's Aircraft, 1996-97,* 375-376; U.S. Army, *Branch Training 1997,* Tab A, 13; U.S. Army, *Branch Training 1996,* Tab A, 7-11; U.S. Army, *FM 44-43,* 3-2; and U.S. Army, *Read Ahead Packet,* U.S. Army, *Read Ahead Packet,* 3-4.

[25] Jackson, *Jane's All the World's Aircraft, 1996-97,* 375-376.

[26] U.S. Army, *Threat Air Capabilities Study,* quoted in U.S. Army, *Branch Training 1997,* Tab A, 11.

[27] U.S. Army, *Branch Training 1997,* Tab D, 8.

[28] U.S. Army, *Field Manual 44-100, US Army Air Defense Operations* (Washington, D.C.: U.S. Government Printing Office, 1995), 3-7, 4-17; These assumptions have been reaffirmed in several SHORAD studies including a JFAAD study on modeling in 1983 by MAJ Otis Ferguson, in which he addressed the impact of the requirement for visual aircraft recognition. "The requirement did not significantly impact on . . . effectiveness since the weapons were either very limited in range or lacked a forward engagement capability. The . . .requirement was also justified by the lack of timely command and control information arriving at the fire unit. . ." Otis Ferguson, MAJ, "Joint Forward Air Defense Model Requirements (JFAAD)," (White Sands Missile Range, NM: , U.S. Army TRADOC Systems Analysis Activity, Sep, 1983), p 2.

[29] Charles Edward Kirkpatrick, MAJ, *Archie in the A.E.F.: The Creation of the Antiaircraft Service of the United States Army, 1917-1918* (Fort Bliss, TX: U.S. Army Air Defense Artillery School, 1984), 63-75.

[30] Kirkpatrick, pp 93-122.

[31] N. W. Routledge, BG, *History of the Royal Regiment of Artillery, Anti-Aircraft Artillery 1914-55* (London: Brassey's UK, 1994) 94-103. HAA units were designed so that radar not only provided them with early warning, but could even track a target and direct the gun's fire. "By 1942, . . .radar permitted aimed, predicted fire by day or night, without the use of visual instruments, as well as providing continuous plotting. By 1944, the latest type of radar display screen could present a gun position, or an operations room, with a second-by-second live plan-position picture of the surrounding airspace from which to make tactical

decisions, the selection of targets and their identification. Automatic tracking was available to replace manual operation." (Routledge, p 76).

To take advantage of this capability and the new HAA gun systems' increased range, the forces had to develop a method to distinguish friend from foe beyond visual target identification range. By 1942 the radio had made electronic identification, Identification Friend from Foe (IFF), possible but it was merely an aid and not foolproof. Not all aircraft carried the equipment, and those that did, might have damaged equipment so that no response from an IFF interrogation did not necessarily mean the target was hostile. Procedural methods, aided by electronic IFF, were the norm for declaring targets hostile. Once this was done in the operations room, and the information was passed to the fire units, HAA gunners could engage with their radar directed systems. (Routledge, pp 76-83, 94-103; Kenneth P. Werrell, *Archie, Flak, AAA, and SAM, A Short Operational History of Ground-Based Air Defense* (Maxwell Air Force Base, Alabama: Air University Press, 1988), 5-6).

[32] Routledge, pp 76, 94-103. LAA units did not possess operations rooms like HAA which could process the information received from radars and then send electronic targeting and aiming instructions to the guns. Even if they had possessed such operations centers, the technology at this time required this data to be passed electronically through cables. Radio did not yet have the capability to send and receive data in a way that would allow a fire unit to track and engage a target the gunner could not see. LAA units were mobile and operated with front line units, they could not be cabled to an operations rooms and still operate with the maneuver units.

[33] Routledge, 57,76-87, 94-104; Officers of the 1st Anti-Aircraft Battalion, comps., *Anti-Aircraft Defense* (n.p. : The Coast Artillery Journal, [circa 1922]), 104; Robert Arthur, ed., *Tactics and Technique of Coast Artillery, Advanced* (Washington, D.C.: The National Publishing Company, 1931), 415-419; Thomas E. Christianson, LTC, "Triple A", *Air Defense Artillery,* (May-June 1994): 10-12; and Kenneth P. Werrell, *Archie, Flak, AAA, and SAM, A Short Operational History of Ground-Based Air Defense* (Maxwell Air Force Base, Alabama: Air University Press, 1988), 2-4.

[34] Werrell, pp 71-81.

[35] Frank J. Caravella, LTC, *First to Fire, Air Defense Artillery Protecting the Force* (Fort Bliss, TX: U.S. Army Air Defense Artillery School, 1995), 83-92; Werrell, 82-90, 95-127; and Joseph Russo, COL, ed. , *Continental Defense of the United States: A Summary history From the 1700s through 1990* (El Paso, TX: privately printed, 1990), 33-37, Appendix C, 2; Air defense and airspace controllers performed the task of target identification in operations centers. These controllers based the identification of the target as hostile on things such as the aircraft's origin, reports from friendly pilots, heading, whether or not the aircraft was following established flight patterns and corridors, and any hostile

acts committed by the aircraft. The new procedures required Army and Air Force units to work closely together and share the air picture and target identification to preclude fratricide.

[36] Caravella, pp 93-132; Werrell, pp 137-168; C. C Smith and M.K. Joiner, "Technical Note 1-83, Aircraft Recognition and Identification Ranges for a Prototype Chaparral Forward Looking Infrared (FLIR) Sensor System," (Aberdeen Proving Grounds, Maryland: U.S. Army Human Engineering Lab, 1983), microfiche, 3-5.

[37] U.S. Army, "Joint Forward Area Air Defense (JFAAD) Literature/Document Search, Review and Summary," (Fort Bliss, TX.: JFAAD, Oct 1983), microfiche ADB079427L, 2-1.

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